

SECTION 02700

POLYETHYLENE GEOMEMBRANE LINER

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Specifications and guidelines for MANUFACTURING and INSTALLING geomembrane.

1.02 REFERENCES

- A. American Society for Testing and Materials (ASTM)
 - 1. D 1004 Test Method for Initial Tear Resistance of Plastic Film and Sheeting
 - 2. D 1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
 - 3. D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
 - 4. D 1603 Test Method for Carbon Black in Olefin Plastics
 - 5. D 3895 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
 - 6. D 4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
 - 7. D 5199 Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
 - 8. D 5397 Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test
 - 9. D 5596 Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
 - 10. D 5994 Standard Test Method for Measuring Core Thickness of Textured Geomembranes
 - 11. D 6392 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
 - 12. D 6693 Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
- B. Geosynthetic Research Institute
 - 1. GRI GM 13 Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

1.03 DEFINITIONS

- A. Lot- A quantity of resin (usually the capacity of one rail car) used in the manufacture of geomembranes. Finished roll will be identified by a roll number traceable to the resin lot used.
- B. Construction Quality Assurance Consultant (CONSULTANT) - Party, independent from MANUFACTURER and INSTALLER that is responsible for observing and documenting activities related to quality assurance during the lining system construction.
- C. ENGINEER- The individual or firm responsible for the design and preparation of the project's Contract Drawings and Specifications.
- D. Geomembrane Manufacturer (MANUFACTURER) - The party responsible for manufacturing the geomembrane rolls.

- E. Geosynthetic Quality Assurance Laboratory (TESTING LABORATORY)- Party, independent from the OWNER, MANUFACTURER and INSTALLER, responsible for conducting laboratory tests on samples of geosynthetics obtained at the site or during manufacturing, usually under the direction of the OWNER.
- F. INSTALLER- Party responsible for field handling, transporting, storing, deploying, seaming and testing of the geomembrane seams.
- G. Panel- Unit area of a geomembrane that will be seamed in the field that is larger than 100 ft².
- H. Patch- Unit area of a geomembrane that will be seamed in the field that is less than 100 ft².
- I. Subgrade Surface- Soil layer surface which immediately underlies the geosynthetic material(s).

1.04 SUBMITTALS POST-AWARD

- A. Furnish the following product data, in writing, to ENGINEER prior to installation of the geomembrane material:
 - 1. Resin Data shall include the following.
 - a. Certification stating that the resin meets the specification requirements (see Section 1.09).
 - 2. Geomembrane Roll
 - a. Statement certifying no recycled polymer and no more than 10% rework of the same type of material is added to the resin (product run may be recycled).
- B. The INSTALLER shall furnish the following information to the ENGINEER and OWNER prior to installation:
 - 1. Installation layout drawings
 - a. Must show proposed panel layout including field seams and details
 - b. Must be approved prior to installing the geomembrane
 - 1. Approved drawings will be for concept only and actual panel placement will be determined by site conditions.
 - 2. Installer's Geosynthetic Field Installation Quality Assurance Plan
- C. The INSTALLER will submit the following to the ENGINEER upon completion of installation:
 - 1. Certificate stating the geomembrane has been installed in accordance with the Contract Documents
 - 2. Material and installation warranties
 - 3. As-built drawings showing actual geomembrane placement and seams including typical anchor trench detail

1.05 QUALITY ASSURANCE

- A. The OWNER will engage and pay for the services of a Geosynthetic Quality Assurance Consultant and Laboratory to monitor geomembrane installation.

1.06 QUALIFICATIONS

- A. MANUFACTURER
 - 1. Geomembrane shall be manufactured by the following:
 - a. GSE Lining Technology, Inc.
 - b. approved equal
 - 2. MANUFACTURER shall have manufactured a minimum of 10,000,000 square feet of polyethylene geomembrane during the last year.

B. INSTALLER

1. INSTALLER shall have installed a minimum of 500,000 square feet of HDPE geomembrane during the last 3 years.
2. INSTALLER shall have worked in a similar capacity on at least 5 projects similar in complexity to the project described in the contract documents, and with at least 50,000 square feet of HDPE geomembrane installation on each project.
3. The Installation Supervisor shall have worked in a similar capacity on projects similar in size and complexity to the project described in the Contract Documents.
4. The INSTALLER shall provide a minimum of one Master Seamer for work on the project.
 - a. Must have completed a minimum of 1,000,000 square feet of geomembrane seaming work using the type of seaming apparatus proposed for the use on this Project.

1.07 MATERIAL LABELING, DELIVERY, STORAGE AND HANDLING

- A. Labeling - Each roll of geomembrane delivered to the site shall be labeled by the MANUFACTURER. The label will identify:
- a. manufacturer's name
 - b. product identification
 - c. thickness
 - d. length
 - e. width
 - f. roll number
- B. Delivery- Rolls of liner will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.
- C. Storage- The on-site storage location for geomembrane material, provided by the CONTRACTOR to protect the geomembrane from punctures, abrasions and excessive dirt and moisture for should have the following characteristics:
- a. level (no wooden pallets)
 - b. smooth
 - c. dry
 - d. protected from theft and vandalism
 - e. adjacent to the area being lined
- D. Handling- Materials are to be handled so as to prevent damage.

1.08 WARRANTY

- A. Material shall be warranted, on a pro-rata basis against Manufacturer's defects for a period of 5 years from the date of geomembrane installation.
- B. Installation shall be warranted against defects in workmanship for a period of 1 year from the date of geomembrane completion.

1.09 GEOMEMBRANE

- A. Material shall be smooth/textured polyethylene geomembrane as shown on the drawings.
- B. Resin
1. Resin shall be new, first quality, compounded and manufactured specifically for producing geomembrane.
 2. Natural resin (without carbon black) shall meet the following minimum requirements:

Property	Test Method	HDPE
Density [g/cm ³]	ASTM D 1505	0.932
Melt Flow Index [g/10 min.]	ASTM D 1238 (190/2.16)	≤ 1.0
OIT [minutes]	ASTM D 3895 (1 atm/200°C)	100

C. Geomembrane Rolls

1. Do not exceed a combined maximum total of 1 percent by weight of additives other than carbon black.
2. Geomembrane shall be free of holes, pinholes as verified by on-line electrical detection, bubbles, blisters, excessive contamination by foreign matter, and nicks and cuts on roll edges.
3. Geomembrane material is to be supplied in roll form. Each roll is to be identified with labels indicating roll number, thickness, length, width and MANUFACTURER.
4. All liner sheets produced at the factory shall be inspected prior to shipment for compliance with the physical property requirements listed in section 1.09, B, and be tested by an acceptable method of inspecting for pinholes. If pinholes are located, identified and indicated during manufacturing, these pinholes may be corrected during installation.

D. Smooth surfaced geomembrane shall meet the requirements shown in table 1.1 for the 60 mil thickness geomembrane.

F. Extrudate Rod or Bead

1. Extrudate material shall be made from same type resin as the geomembrane.
2. Additives shall be thoroughly dispersed.
3. Materials shall be free of contamination by moisture or foreign matter.

1.10 EQUIPMENT

A. Welding equipment and accessories shall meet the following requirements:

1. Gauges showing temperatures in apparatus (extrusion welder) or wedge (wedge welder) shall be present.
2. An adequate number of welding apparati shall be available to avoid delaying work.
3. Power source must be capable of providing constant voltage under combined line load.

1.11 DEPLOYMENT

A. Assign each panel a simple and logical identifying code. The coding system shall be subject to approval and shall be determined at the job site.

B. Visually inspect the geomembrane during deployment for imperfections and mark faulty or suspect areas.

C. Deployment of geomembrane panels shall be performed in a manner that will comply with the following guidelines:

1. Unroll geomembrane using methods that will not damage geomembrane and will protect underlying surface from damage (spreader bar, protected equipment bucket).
2. Place ballast (commonly sandbags) on geomembrane which will not damage geomembrane to prevent wind uplift.
3. Personnel walking on geomembrane shall not engage in activities or wear shoes that could damage it. Smoking will not be permitted on the geomembrane.
4. Do not allow heavy vehicular traffic directly on geomembrane. Rubber-tired ATV's and trucks are acceptable if wheel contact is less than 6 psi.

5. Protect geomembrane in areas of heavy traffic by placing protective cover over the geomembrane.
- D. Sufficient material (slack) shall be provided to allow for thermal expansion and contraction of the material.

1.12 FIELD SEAMING

- A. Seams shall meet the following requirements:
1. To the maximum extent possible, orient seams parallel to line of slope, i.e., down and not across slope.
 2. Minimize number of field seams in corners, odd-shaped geometric locations and outside corners.
 3. Slope seams (panels) shall extend a minimum of five-feet beyond the grade break into the flat area.
 4. Use a sequential seam numbering system compatible with panel numbering system that is agreeable to the CONSULTANT and INSTALLER.
 5. Align seam overlaps consistent with the requirements of the welding equipment being used. A 6-inch overlap is commonly suggested.
- B. During Welding Operations
1. Provide at least one Master Seamer who shall provide direct supervision over other welders as necessary.
- C. Extrusion Welding
1. Hot-air tack adjacent pieces together using procedures that do not damage the geomembrane.
 2. Clean geomembrane surfaces by disc grinder or equivalent.
 3. Purge welding apparatus of heat-degraded extrudate before welding.
- D. Hot Wedge Welding
1. Welding apparatus shall be a self-propelled device equipped with an electronic controller which displays applicable temperatures.
 2. Clean seam area of dust, mud, moisture and debris immediately ahead of hot wedge welder.
 3. Protect against moisture build-up between sheets.
- E. Trial Welds
1. Perform trial welds on geomembrane samples to verify welding equipment is operating properly.
 2. Make trial welds under the same surface and environmental conditions as the production welds, i.e., in contact with subgrade and similar ambient temperature.
 3. Minimum of two trial welds per day, per welding apparatus, one made prior to the start of work and one completed at mid shift.
 4. Cut four, one-inch wide by six-inch long test strips from the trial weld.
 5. Quantitatively test specimens for peel adhesion, and then for shear strength.
 6. Trial weld specimens shall pass when the results shown in Table 3 are achieved in both peel and shear test.
 - a. The break, when peel testing, occurs in the liner material itself, not through peel separation (FTB).
 - b. The break is ductile.
 7. Repeat the trial weld, in its entirety, when any of the trial weld samples fail in either peel or shear.
 8. No welding equipment or welder shall be allowed to perform production welds until equipment and welders have successfully completed trial weld.

- F. Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. INSTALLER shall demonstrate that acceptable seaming can be performed by completing acceptable trial welds.
- G. Defects and Repairs
 - 1. Examine all seams and non-seam areas of the geomembrane for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.
 - 2. Repair and non-destructively test each suspect location in both seam and non-seam areas. Do not cover geomembrane at locations that have been repaired until test results with passing values are available.

1.13 FIELD QUALITY ASSURANCE

- A. MANUFACTURER and INSTALLER shall participate in and conform to all terms and requirements of the Owner's quality assurance program. CONTRACTOR shall be responsible for assuring this participation.
- B. Quality assurance requirements are as specified in this Section and in the Field Installation Quality Assurance Manual if it is included in the contract.
- C. Field Testing
 - 1. Non-destructive testing may be carried out as the seaming progresses or at completion of all field seaming.
 - a. Vacuum Testing
 - 1) Shall be performed in accordance with ASTM D 5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
 - b. Air Pressure Testing
 - 1) Shall be performed in accordance with ASTM D 5820, Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
 - c. Other approved methods.
 - 2. Destructive Testing (performed by CONSULTANT with assistance from INSTALLER)
 - a. Location and Frequency of Testing
 - 1) Collect destructive test samples at a frequency of one per every 1500 lineal feet of seam length.
 - 2) Test locations will be determined after seaming.
 - 3) Exercise Method of Attributes as described by GRI GM-14 (Geosynthetic Research Institute, <http://www.geosynthetic-institute.org>) to minimize test samples taken.
 - b. Sampling Procedures are performed as follows:
 - 1) INSTALLER shall cut samples at locations designated by the CONSULTANT as the seaming progresses in order to obtain field laboratory test results before the geomembrane is covered.
 - 2) CONSULTANT will number each sample, and the location will be noted on the installation as-built.
 - 3) Samples shall be twelve (12) inches wide by minimal length with the seam centered lengthwise.
 - 4) Cut a 2-inch wide strip from each end of the sample for field-testing.
 - 5) Cut the remaining sample into two parts for distribution as follows:
 - a) One portion for INSTALLER, 12-inches by 12 inches
 - b) One portion for the Third Party laboratory, 12-inches by 18-inches
 - c) Additional samples may be archived if required.
 - 6) Destructive testing shall be performed in accordance with ASTM D 6392, Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.

- 7) INSTALLER shall repair all holes in the geomembrane resulting from destructive sampling.
 - 8) Repair and test the continuity of the repair in accordance with these Specifications.
3. Failed Seam Procedures
- 1) If the seam fails, INSTALLER shall follow one of two options:
 - a) Reconstruct the seam between any two passed test locations.
 - b) Trace the weld to intermediate location at least 10 feet minimum or where the seam ends in both directions from the location of the failed test.
 - 2) The next seam welded using the same welding device is required to obtain an additional sample, i.e., if one side of the seam is less than 10 feet long.
 - 3) If sample passes, then the seam shall be reconstructed or capped between the test sample locations.
 - 4) If any sample fails, the process shall be repeated to establish the zone in which the seam shall be reconstructed.

1.14 REPAIR PROCEDURES

- A. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.
- B. Repair any portion of unsatisfactory geomembrane or seam area failing a destructive or non-destructive test.
- C. INSTALLER shall be responsible for repair of defective areas.
- D. Agreement upon the appropriate repair method shall be decided between CONSULTANT and INSTALLER by using one of the following repair methods:
 1. Patching- Used to repair large holes, tears, undispersed raw materials and contamination by foreign matter.
 2. Abrading and Re-welding- Used to repair short section of a seam.
 3. Spot Welding- Used to repair pinholes or other minor, localized flaws or where geomembrane thickness has been reduced.
 4. Capping- Used to repair long lengths of failed seams.
 5. Flap Welding- Used to extrusion weld the flap (excess outer portion) of a fusion weld in lieu of a full cap.
 6. Remove the unacceptable seam and replace with new material.
- E. The following procedures shall be observed when a repair method is used:
 1. All geomembrane surfaces shall be clean and dry at the time of repair.
 2. Surfaces of the polyethylene which are to be repaired by extrusion welds shall be lightly abraded to assure cleanliness.
 3. Extend patches or caps at least 6 inches for extrusion welds and 4 inches for wedge welds beyond the edge of the defect, and around all corners of patch material.
- F. Repair Verification
 1. Number and log each patch repair (performed by CONSULTANT).
 2. Non-destructively test each repair using methods specified in this Specification.

1.15 MEASUREMENT AND PAYMENT

- A. Payment for geomembrane installation will be as per contract unit price per square foot, as measured parallel to liner surface, including designed anchor trench material and is based upon net lined area.

- B. Net lined area is defined to be the true area of all surfaces to be lined plus designed burial in all anchor trenches, rubsheets, and sacrificial layers.
- C. Prices shall include full compensation for furnishing all labor, material, tools, equipment, and incidentals.
- D. Prices also include doing all the work involved in performing geomembrane installation completely as shown on the drawing, as specified herein, and as directed by the ENGINEER.

Table 1.1: Minimum Values for Smooth Black-Surfaced HDPE Geomembranes

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM VALUE				
Product Code			HDE 030A000	HDE 040A000	HDE 060A000	HDE 080A000	HDE 100A000
Thickness, (minimum average) mil (mm) Lowest individual reading (-10%)	ASTM D 5199	every roll	30 (0.75) 27 (0.69)	40 (1.00) 36 (0.91)	60 (1.50) 54 (1.40)	80 (2.00) 72 (1.80)	100 (2.50) 90 (2.30)
Density, g/cm ³	ASTM D 1505	200,000 lb	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction)	ASTM D 6693, Type IV Dumbbell, 2 ipm	20,000 lb	114 (20) 63 (11)	152 (27) 84 (15)	228 (40) 126 (22)	304 (53) 168 (29)	380 (67) 210 (37)
Strength at Break, lb/in-width (N/mm)							
Strength at Yield, lb/in-width (N/mm)							
Elongation at Break, %	G.L. 2.0 in (51 mm)		700	700	700	700	700
Elongation at Yield, %	G.L. 1.3 in (33 mm)		12	12	12	12	12
Tear Resistance, lb (N)	ASTM D 1004	45,000 lb	21 (93)	28 (125)	42 (187)	56 (249)	70 (311)
Puncture Resistance, lb (N)	ASTM D 4833	45,000 lb	54 (240)	72 (320)	108 (480)	144 (640)	180 (800)
Carbon Black Content, %	ASTM D 1603	20,000 lb	2.0	2.0	2.0	2.0	2.0
Carbon Black Dispersion	ASTM D 5596	45,000 lb	+Note 1	+Note 1	+Note 1	+Note 1	+Note 1
Notched Constant Tensile Load, hr	ASTM D 5397, Appendix	200,000 lb	300	300	300	300	300
REFERENCE PROPERTY	TEST METHOD	FREQUENCY	NOMINAL VALUE				
Oxidative Induction Time, min	ASTM D 3895, 200° C; O ₂ , 1 atm	200,000 lb	>100	>100	>100	>100	>100
Roll Length ⁽¹⁾ (approximate), ft (m)			1,120 (341)	870 (265)	560 (171)	430 (131)	340 (104)
Roll Width ⁽¹⁾ , ft (m)			22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)
Roll Area, ft ² (m ²)			25,200 (2,341)	19,575 (1,819)	12,600 (1,171)	9,675 (899)	7,650 (711)

NOTES:

- +Note 1: Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- GSE HD is available in rolls weighing about 3,900 lb (1,769 kg)
- All GSE geomembranes have dimensional stability of ±2% when tested with ASTM D 1204 and LTB of <77° C when tested with ASTM D 746.
- ⁽¹⁾Roll lengths and widths have a tolerance of ± 1%.

Table 3.1: Minimum Weld Values for HDPE Geomembranes

Property	Test Method	60 (1.5)
Peel Strength (fusion), ppi (kN/m)	ASTM D 6392	98 (17.2)
Peel Strength (extrusion), ppi (kN/m)	ASTM D 6392	78 (13.7)
Shear Strength (fusion & ext.), ppi (kN/m)	ASTM D 6392	121 (21.2)

END OF SECTION

